# NIST Role and Capabilities for Supporting Expanded Use of Biofuels

**Willie E. May and Ellyn Beary**
Chemical Science and Technology Laboratory
National Institute of Standards and Technology
Gaithersburg, Maryland U.S.A.

# Outline

- Why Increased Interest in Biofuels
- Why NIST
  - Consistent with Mission and Weights and Measures Responsibility
  - Commitment at JCM to work with INMETRO on metrology-related issues
- Relevant Capabilities and Facilities

# Why Increased Interest in Biofuels

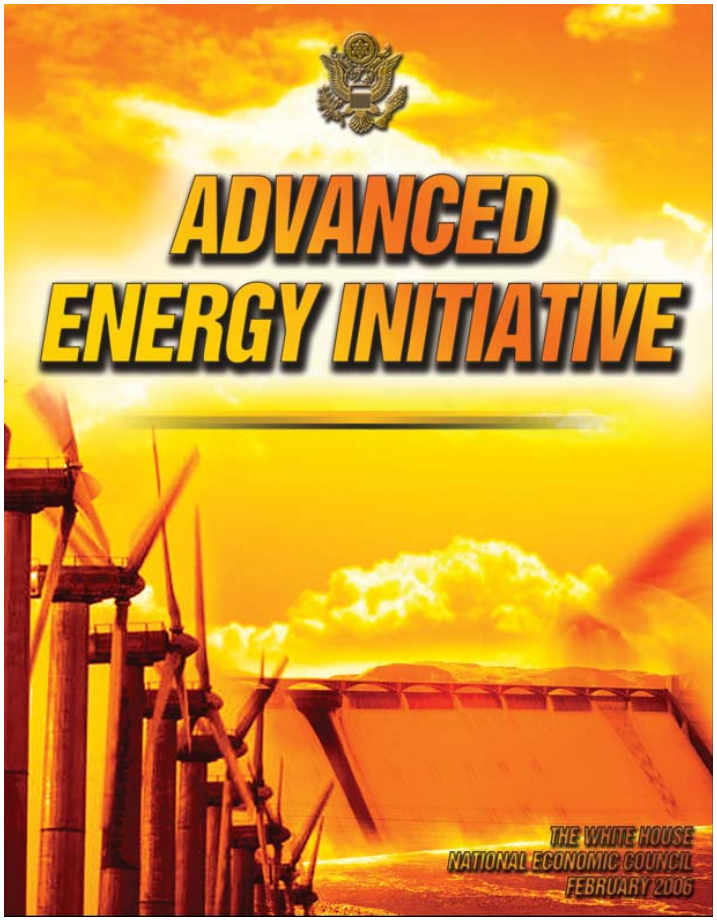
# *"Energy Crisis"*

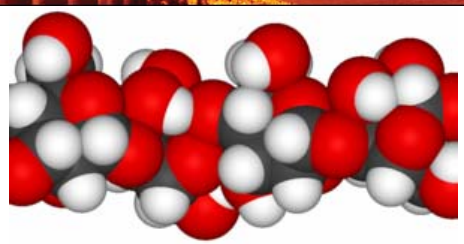
**Timing is Right to Explore Alternative Fuels for Transportation**

*because of*:

- Economics of Fossil Fuel-based Economy
- Perceived to be an Answer to Environmental Concerns
- Social Readiness
- Advances in Science and Technology
- Governmental Commitment to address this problem

# US has issued Policies and Initiatives



3D image of cellulose

***For Changing the way we power our automobiles:***

***More Efficient Vehicles:*** electric hybrid
***Hydrogen Fuel Initiative:*** fuel cells

***The Biorefinery Initiative:***
***Accelerating research into "cellulosic ethanol" can make it cost-competitive by 2012, offering the potential to displace up to 30% of the current US fuel use.***

We must also change how we power our automobiles … fund additional research in cutting-edge methods of producing ethanol, not just from corn, but from wood chips and stalks, or switch grass. Our goal is to make this new kind of ethanol practical and competitive within six years.

**GW Bush**
**State of the Union Address, 2006**

↺ Return

## Why NIST:

Consistent with Mission and Weights and Measures Responsibility

# National Institute of Standards and Technology

NIST is a
**non-regulatory agency**
in the
**Technology Administration**
of the
**US Department of Commerce.**

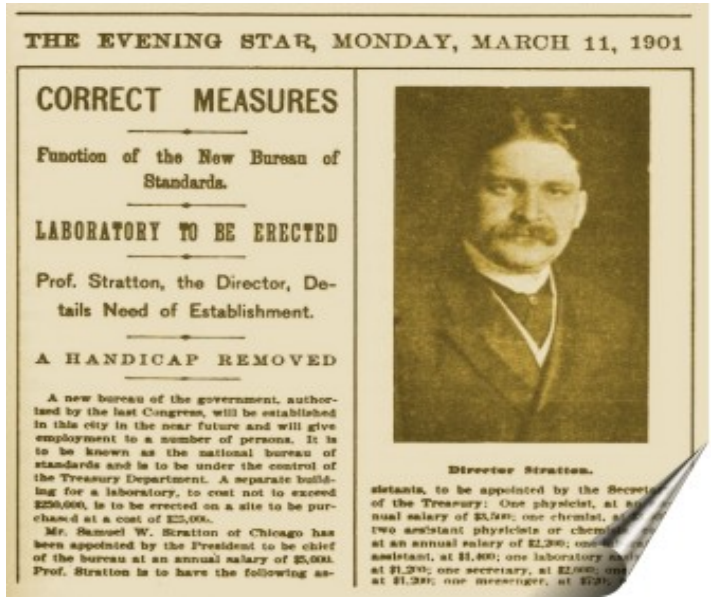

***Mission*** **... to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life**

# NBS Organic Act of 1901

"It is therefore the unanimous opinion of your committee that no more essential aid could be given to

- **manufacturing**
- **commerce**
- **the makers of scientific apparatus**
- **the scientific work of Government**
- **schools, colleges, and universities**

than by the establishment of the institution proposed in this bill."



THE EVENING STAR, MONDAY, MARCH 11, 1901

CORRECT MEASURES

Function of the New Bureau of Standards.

LABORATORY TO BE ERECTED

Prof. Stratton, the Director, Details Need of Establishment.

A HANDICAP REMOVED

A new bureau of the government, authorized by the last Congress, will be established in this city in the near future and will give employment to a number of persons. It is to be known as the national bureau of standards and is to be under the control of the Treasury Department. A separate building for a laboratory, to cost not to exceed $250,000, is to be erected on a site to be purchased at a cost of $25,000.

Mr. Samuel W. Stratton of Chicago has been appointed by the President to be chief of the bureau at an annual salary of $5,000. Prof. Stratton is to have the following as-

Director Stratton.

sistants, to be appointed by the Secretary of the Treasury: One physicist, at a annual salary of $3,500; one chemist, at two assistant physicists or chemists at an annual salary of $2,000; one assistant, at $1,600; one laboratory at $1,200; one secretary, at $1,200; one messenger, at $720

- **Custody of the standards;**
- **Comparison of the standards** used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted by or recognized by the Government;
- **Construction of standards**, their multiples and subdivisions;
- **Testing and calibration** of standard measuring apparatus;
- **Solution of standards problems;** and,
- **Determination of physical constants and the properties of materials,** when such data are of great importance and are not to be obtained of sufficient accuracy elsewhere.

# Weights and Measures: Bringing Equity to the Marketplace



***From laboratory, primary fluid-flow and volume standards***

***To assisting the States in their Weights and Measures regulation***

↺ Return

**NIST Handbook 44 (2002): http://ts.nist.gov/ts/htdocs/230/235/h442002.htm**

## Why NIST:

Commitment at JCM to work with INMETRO on metrology-related issues

# U.S. - Brazil Science and Technology Ministerial Joint Committee Meeting

## July 21, 2006

*It was agreed to establish a collaborative program on metrology and standards for biofuels. As a first step, a workshop entitled …… will be held in Rio de Janeiro September 14-15.*

*This meeting will focus on measurements and standards issues regarding the production, distribution and quality of biofuels*

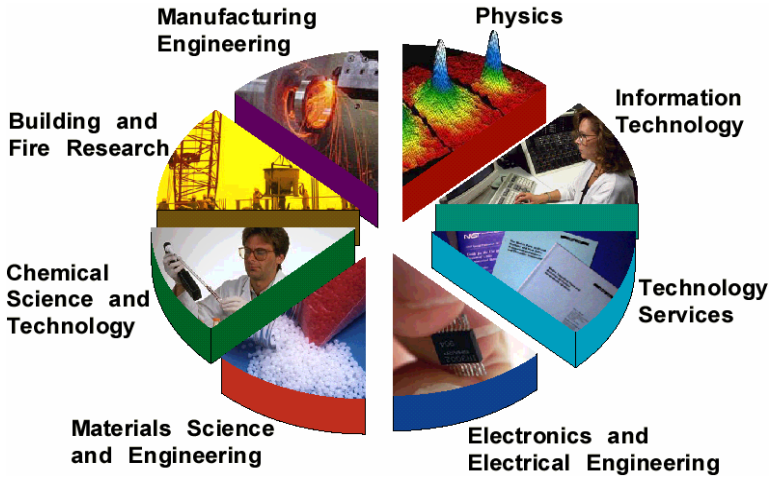
***The results of these discussions will form the basis of joint measurement research and standards development activities between NIST and INMETRO***

↺ Return

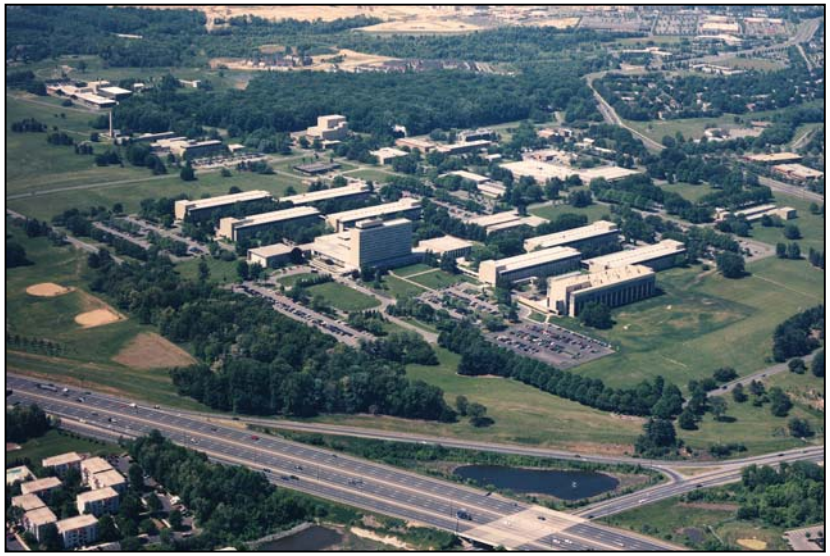
# NIST has Relevant Capabilities, Facilities and Programs

# NIST: A Premier Scientific Institution

- World-leading measurement science and standards program
- ~1,400 technical staff including ~700 PhD scientists and engineers
  - 3 Nobel Laureates since 1997
  - MacArthur Fellowship winner in 2003
  - National Medal of Science winner in 1998
  - 14 National Academy Members
  - ~120 National Society Fellows and recipients of ~60 National/International Awards per year
- Partnerships with industry, academia, and other government agencies have been an integral part of NIST culture since 1901.



# NIST has world-class research laboratories, state-of-the-art equipment, and unique research facilities



## Gaithersburg, MD Campus

**580 acre site** with **29 laboratory buildings** and 780,000 sq. ft. of laboratory space (72,500 $m^2$)

## Boulder, Colorado Campus

**205 acre site** with **9 laboratory buildings** and 151,000 sq. ft. of laboratory space (14,000 $m^2$)

# ..and conducts research in three joint Institutes

## CARB
## University of Maryland

Research in fundamental problems at the forefront of biotechnology focusing on structural biology, bioinformatics, proteomics, plant and insect transformation

## JILA
## University of Colorado

Center for teaching and research in atomic, chemical, optical, laser, gravitational, and solar physics; semiconductors; precision measurement; astrophysics; astronomy; and now bioscience

## HML
## Charleston, SC

Research in science and biotechnology to understand linkages between environmental condition and the health of marine organisms and humans

# Has Some Unique Research Facilities

### *NIST Advanced Measurement Laboratory*

- Five Building Complex with stringent control of temperature, vibration, humidity, cleanliness
- State-of-the-art nano-fabrication capabilities, in the 110,000 sq ft Cleanroom Building

### *NIST Center for Neutron Research*

The NCNR is a national center for research offering advanced thermal and cold neutron measurement capabilities to researchers from industry, academia and government agencies in the U.S.A.

# The NIST Center for Neutron Research (NCNR) Guidehall

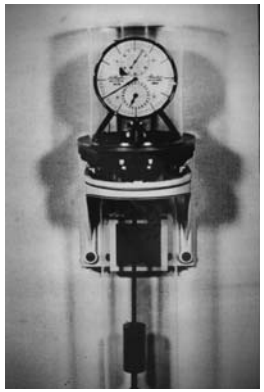
- The only U.S. capability for studies of biological dynamics, both temporal and spatial information are obtained.

- Neutron methods at the NCNR encompass an enormous range of time and length scales.

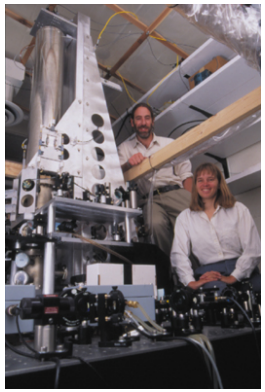
# NIST fulfills the traditional NMI function:

## *the development & dissemination of primary standards*

pendulum clock
1 s in 3 years
(1904)

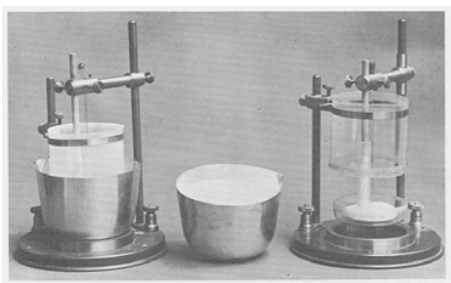


second

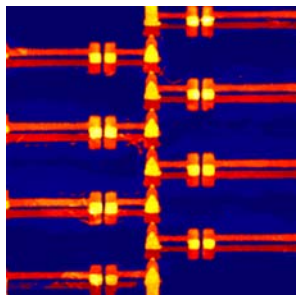


NIST F1
atomic clock
1 s in 30 million
years
(1999)

silver voltameter
current standard
(1910)



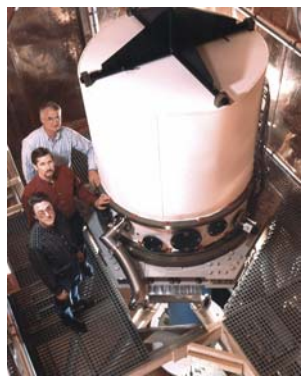
ampere



single
electron
counter
(20xx)

physical artifact
(1889)

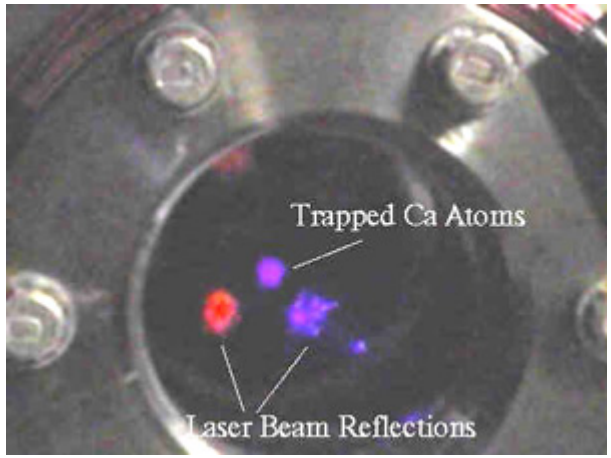
kilogram



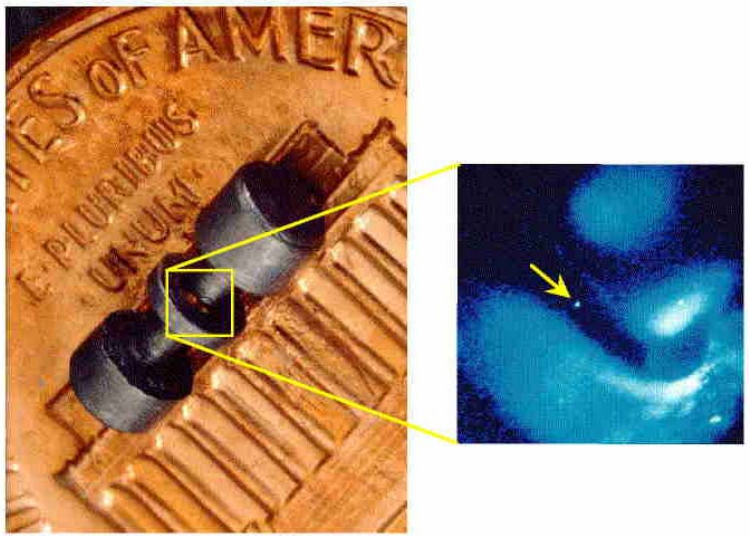
electronic
kilogram
(20xx)

# NIST Research to Develop Future Clocks

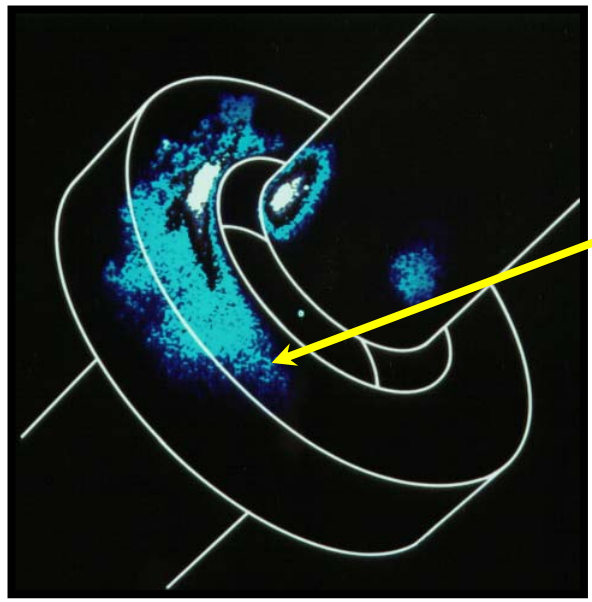
Optical clocks have the potential for accuracy about 1,000 times better than NIST F-1
($10^{-18}$, 1 second in 30 billion years).




**Laser-cooled calcium trap.**



**Single mercury ion trap.**

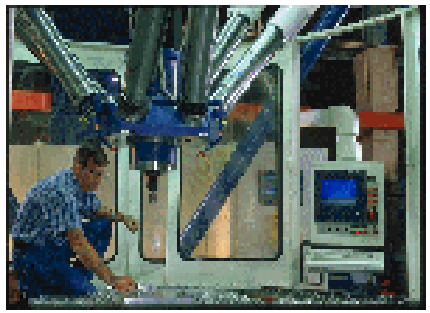


**Single Ion**

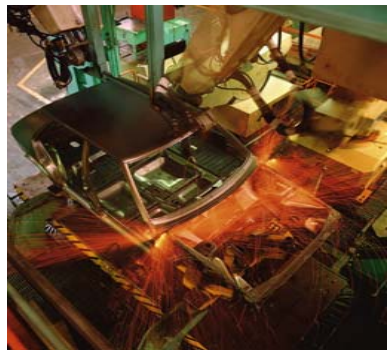
# … but also serves a broad customer base …

## *with constantly changing measurement and standards needs*


Environmental Technologies



Manufacturing



Transportation

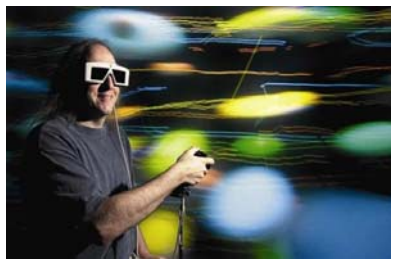
Pharmaceuticals

Food and nutrition

Construction

Law enforcement

Biotechnology



Computer software and equipment

Microelectronics

# NIST research and measurement service activities

## ...facilitate trade

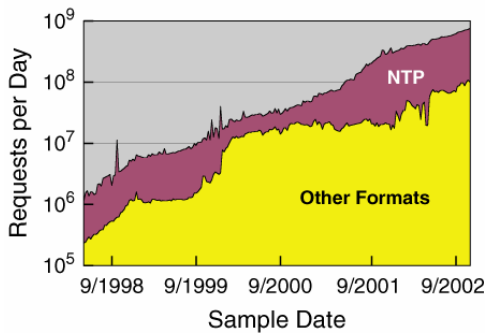
secure automated banking

electric power metering

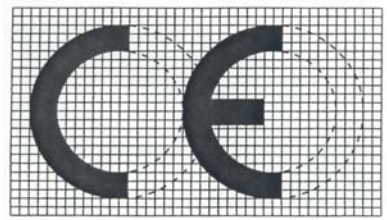


national standards to counteract TBTs

volume and flow standards



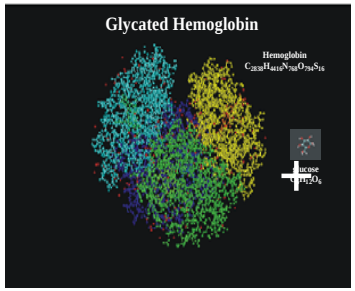

www.time.gov
billions of hits daily



EU directive on in vitro diagnostic standards

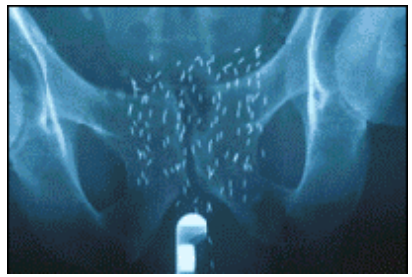
# NIST research and measurement service activities

## *… improve disease prevention, diagnostics and treatment*

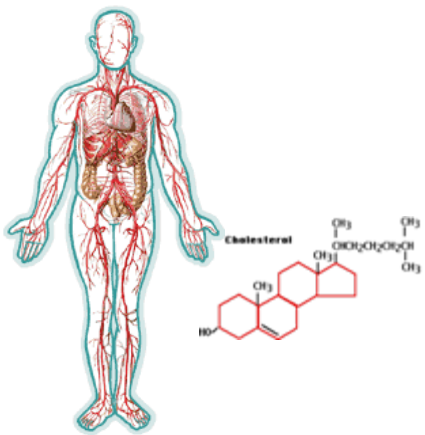


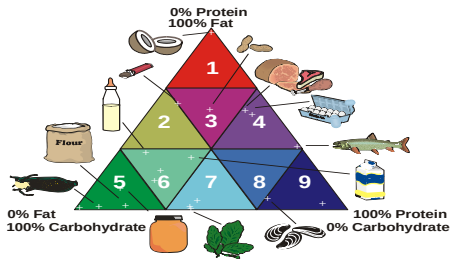

**Standards for clinical diagnostics**

**QA water quality measurements**

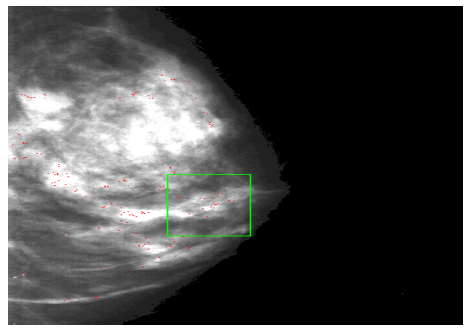


**Dosimetry standards for Prostate Cancer treatment**




**Standards for nutritional labeling**

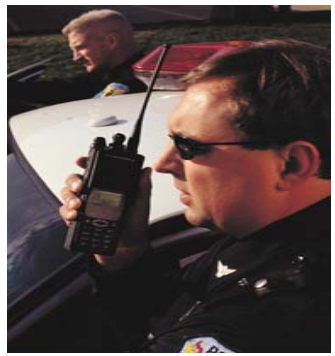


**Standards for Mammography**

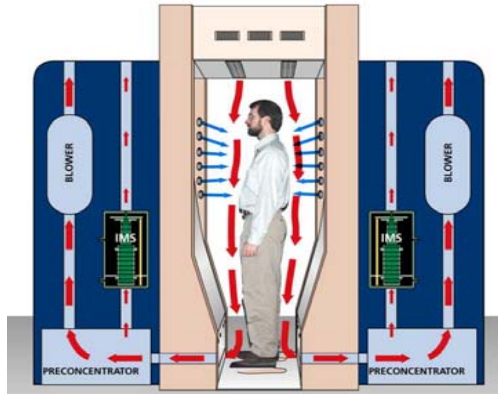
# NIST research and measurement service activities

## *...improve public safety and security*

**gas mask performance standards**



**wireless interoperability standards for first responders**



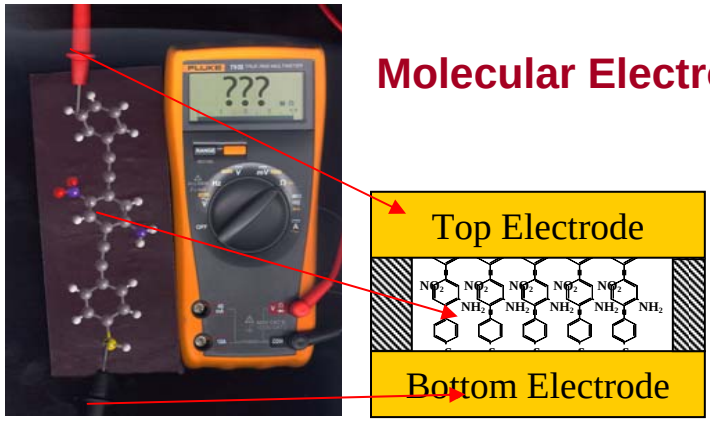

**assessment of detection technology for trace explosives**

**mail irradiation technology**

**altimeter calibration**

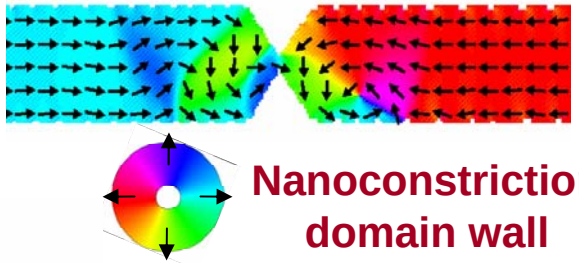
**standards for body biometrics and body armor**

# Measurements, Standards, & Data for the Nanoscale



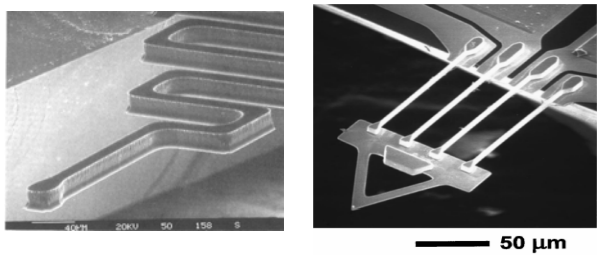

## Molecular Electronics

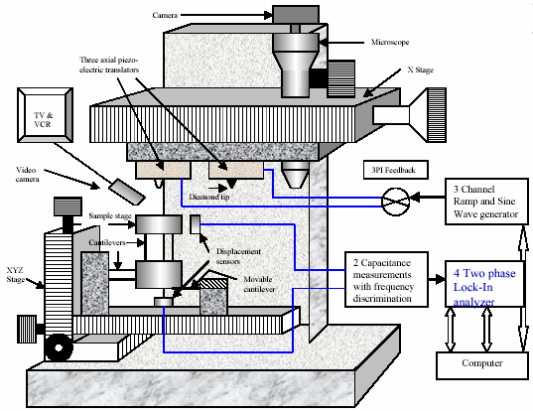
## Imaging Magnetic Nanostructures



Nanoconstriction domain wall

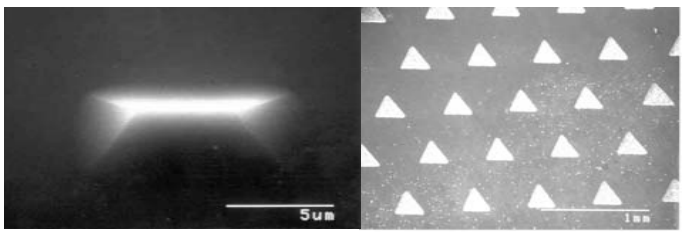
## Cantilever Fabrication for Lateral Force Measurement

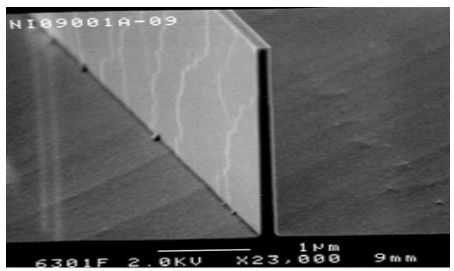


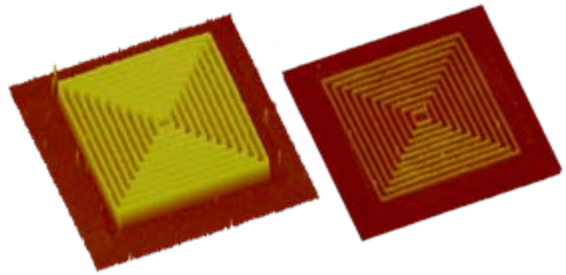

## Nanomechanics and Tribology Measurements

## Surface Standards for Biomaterials



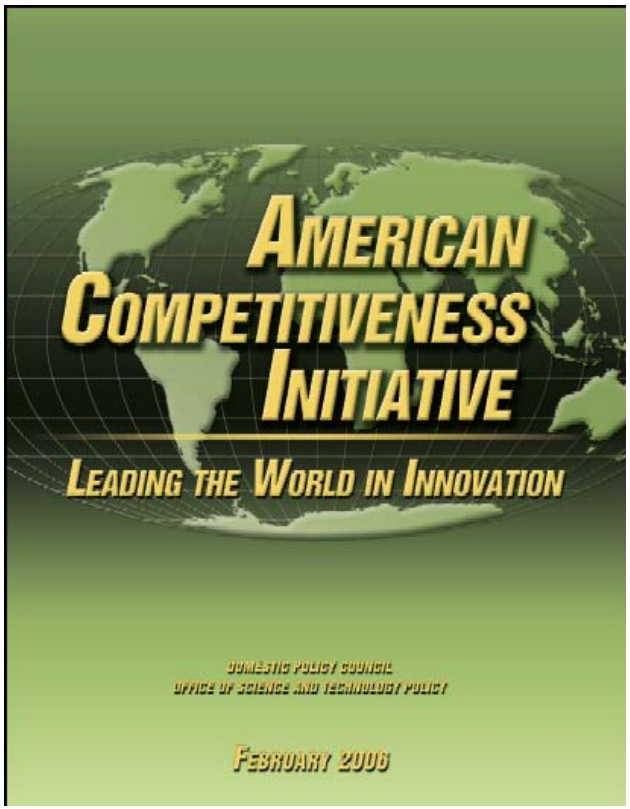




## Nanoscale Dimensional Standards



## Linewidth Standards

# American Competitiveness Initiative
## … announced in 2006 State of the Union Address




***$50B to be invested over the next 10 years in:***

- NIST core (laboratory and infrastructure)
- National Science Foundation
- DOE Office of Science

*The role of government is not to create wealth. The role of our government is to create an environment in which the entrepreneur can flourish, in which minds can expand, in which technologies can reach new frontiers.*

# NIST Increase in the President's FY 2007 Budget Request

- ***Targeting the most strategic and rapidly developing technologies***
  - Nano Discovery to Manufacture
  - **Enabling the Hydrogen Economy**
  - Quantum Information Science – Infrastructure for 21st Century
  - Innovations in Measurement Science
  - Cybersecurity: Innovative Technologies for National Security

- ***Increasing the capacity and capability of critical national assets***
  - NIST Center for Neutron Research (NCNR) Capacity and Capability
  - Synchrotron Measurement Science and Technology

- ***Meeting the Nation's most immediate needs***
  - Manufacturing Innovation through Supply Chain Integration
  - Structural Safety in Hurricanes, Fires, and Earthquakes
  - International Standards and Innovation: Opening Markets
  - Bioimaging: A 21st Century Toolbox for Medical Technology
  - Biometrics: Identifying Friend or Foe

# Four Challenges

Photo © Robert Rathe

## Making Better Fuel Cells

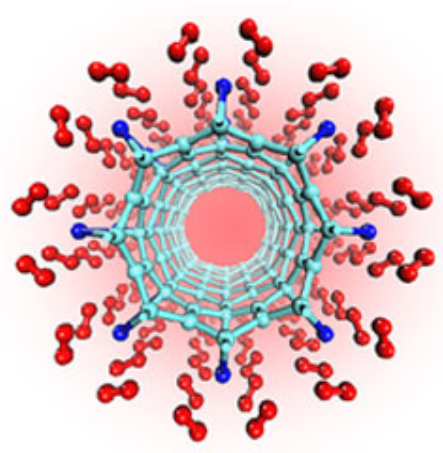


Figure Credit: NIST (Taner Yildirim)

## Storing More Hydrogen


Figure Credit: http://hcsp.ansi.org/vehicle_system.asp

## Creating Consensus Standards


Photo Credit: Shell Oil Co.

## Ensuring Fair Trade

# Hydrogen Economy Program Plan

**Making Better Fuel Cells**

- Imaging and Characterization
- Manufacturing Metrology

**Storing More Hydrogen**

- Neutron Characterization Methods
- Design Tools

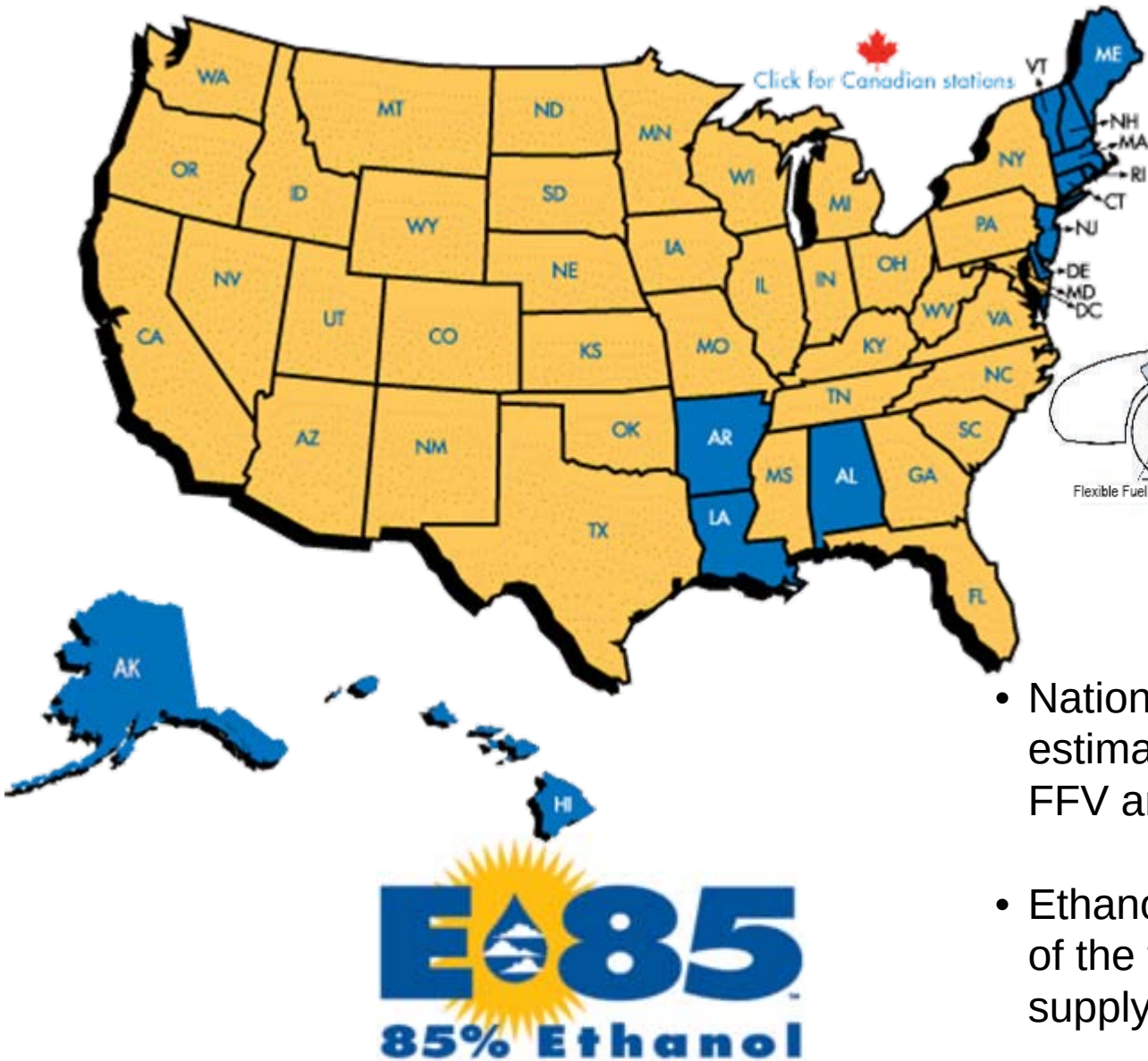
**Creating Consensus Standards**

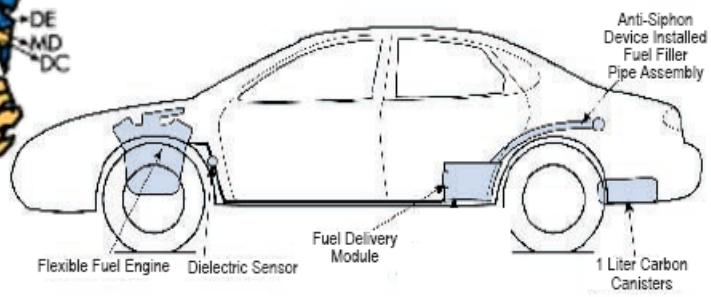
- On the Built Environment
- On Transport, Storage, and Delivery

**Ensuring Fair Trade**

- Metering
- Model Regulations

# Availability of E85 in US (by State)




**Flexible Fuel System**

- National Ethanol Vehicle Coalition estimates that about 6 million FFV are on the road in the US
- Ethanol now represents just 3% of the total annual gasoline supply in the US

E85
85% Ethanol

# Proposed US Federal Regulations Biodiesel and E85 Fuel Requirements

- Energy Policy Act of 2005 amended the Clean Air Act to establish a ***Renewable Fuel Standard*** program
  - Specifies fuel quality standards:
    - 2006 Edition of NIST Handbook 130 national model regulations

      **http://ts.nist.gov/ts/htdocs/230/235/h130-04.htm**
    - Biodiesel intended for blending must meet appropriate ASTM standard specifications
- Will increase the volume of renewable fuel required to be blended into gasoline, starting with 4.0 billion gallons in calendar year 2006 and nearly doubling to 7.5 billion gallons by 2012.

# Technical Challenges for Ethanol

- Fuel Composition and Energy Content
- Impact of New Biofuels on Materials
  (e.g., engine parts, fuel tanks, fuel lines and pumps, etc.)
- Impact of New Biofuels on Environment and Health
  (as they relate to production, distribution, and engine emissions)
- Source Identification

# Wide variety of relevant strengths and measurement capabilities…

***For example:***

- Rigorous application of physical sciences to biological problems and biotechnology
  - Biocatalysis, structural biology, molecular mechanisms, bioimaging, biospectroscopy, tissue engineering, bio MEMS, biomaterials metrology
- Chemical Measurement Science
  - process measurement and sensing technology, chemical composition measurements, separation science, thermophysical property measurements and data, surface chemistry and reactivity, computational chemistry, modeling and measurements of high-temperature reacting flows.
- Materials Science
  - Thermal and mechanical properties, thin film growth, failure analysis, high-performance ceramics, metallurgy, polymers, neutron imaging
- Optical Technology and Spectroscopy
  - Laser cooling and trapping, femtosecond laser spectroscopy, infrared and terahertz spectroscopy, optical and nanoscale probe microscopies, spectrophotometry, ultraviolet and ionizing radiation processing
- Standards Development and Deployment

# Example of Relevant Materials Research

NIST National Institute of Standards and Technology

CSM Colorado School of Mines

## Database for Solder Properties with Emphasis on New Lead-free Solders

Release 4.0

National Institute of Standards & Technology and
Colorado School of Mines

**Lead-Free Solders Research Programs at Universities**

The following are established research centers with Lead-Free Solders programs:

- Alabama Microelectronics Science and Technology Center - Auburn University
- Packaging Research Center - Georgia Institute of Technology
- Reliable Microelectronics Packaging Program - University of California at Berkeley
- Center for Welding, Joining and Coatings Research - Colorado School of Mines
- Integrated Electronics Engineering Center - State University of New York at Binghamton
- Ames Laboratory and Iowa State University
- CALCE Electronic Products and Systems Center - University of Maryland NEW
- Centre for Microelectronics Assembly and Packaging - University of Toronto NEW

**OBJECTIVE**

The purpose of this web site is to provide an on-line database for solder properties emphasizing new lead-free solders. Lead-free solder data are being developed rapidly, but are still difficult to find. (See the Alloy Database section in the August 29, 2000 press release on the NEMI web site - www.nemi.org). Therefore, we hope this web site will allow us to collect this information in one place, and update it frequently. If you have additional data to contribute, please send it to the contact at the bottom of this page. The data reported in this site has been collected from reliable sources and orderly put together. There is no restriction to access the datafile. The user is able to read the data on HTML format and download in WORD format, which then can be formatted in EXCEL for easier manipulation.

**DATAFILES**

The datafiles are ordered by the date in which they were placed on-line, to see them click on one of the links below. If you would like to download the file, click on WORD FORMAT, then go to file and save the document.

| HTML FORMAT | MS WORD FORMAT |
|---|---|
| • Properties of Lead-free Solders. RELEASE 4.0 2002 February 11 8:30:50 pm | • Properties of Lead-free Solders. RELEASE 4.0 2002 February 11 8:30:50 pm |

**Pb-based solder is incompatible with E85 fuel**

Pb-free solder database prepared due to support compliance with “green” EU directives (WEEE, RoHS, REACH, EuP)

# Advanced Isotope Ratio Measurements Identify Unique Manufacturing Process

… a traditional process to manufacture PPT uses high-purity 1,3-propanediol (PDO). PDO is expensive and manufactured from acrolein, a caustic and toxic chemical derived from petroleum.

*non-renewable*

C 14/12 = $10^{-12}$
C 13/12 = 0.0111

**Polypropylene Terephthalate (PPT) based fiber is expected to supplant Polyethylene Terephthalate (PET) based fiber because of product desirability. PET is a *multi-billion dollar global industry.***

- Polymers from new and old process chemically indistinguishable
- Measurement strategy needed to protect industrial investment
- *Carbon-14 and carbon-13 measurements provided means to legally authenticate polymer from new bioprocess*

DuPont Sorona®

DuPont teamed with the international biotechnology firm, Genencor, to genetically design a yeast that could convert glucose (in corn syrup) to PDO.

*renewable*

C 14/12 ~ $10^{-15}$
C 13/12 = 0.0109

# Examples Current Fuels-Related Research and Standards Activities

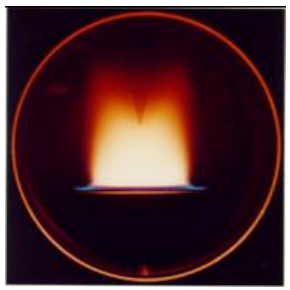
**Biocatalysis:** making chemical products from biomass

**Standards and property data for fossil fuels:**

- ***Real Fuels Program:*** Understanding transportation fuels to determine properties and performance
- ***Fossil Fuel standards:*** Certified for chemical composition

**Gas pipeline integrity, safety, and reliability:** Materials properties related to storage, and transport

**Alcohol-fuel blends:** combustion characteristics, droplet vaporization profiles, sooting tendency as a function of composition



**Properties of alternative fuels for transportation:**
hydrogen-enriched fuels; alternative oxidizers; safer fuels

- Data and standards for fuels and lubricants
- Aircraft fuel tank safety – modeling fuel vapor behavior
- Fire safety of alternative fuels.
- Fuel-cell imaging in actively operating fuel cells

# Examples of NIST's Current Fuels-Related Activities

**Combustion Data:** chemistry (kinetics) and mixing (fluid dynamics)
**Output:** data and simulation models

**Evaluation Standards:** Reference liquids (octane rating as specified in ASTM Manual for Rating Motor, Diesel, and Aviation Fuels), Catalyst package (oxidation stability used in ASTM D 4742, Standard Test Method )

**Chemical Composition Standards:** Diesel fuel, kerosene, fossil fuels, residual fuel oil

**Instrument Calibration:** Combustion Calorimetry standards (e.g. combustion bomb calorimeters), Optical Properties standards (e.g. calibration of fluorescence spectrometers), Molecular Absorption standards (e.g. spectrophotometry)

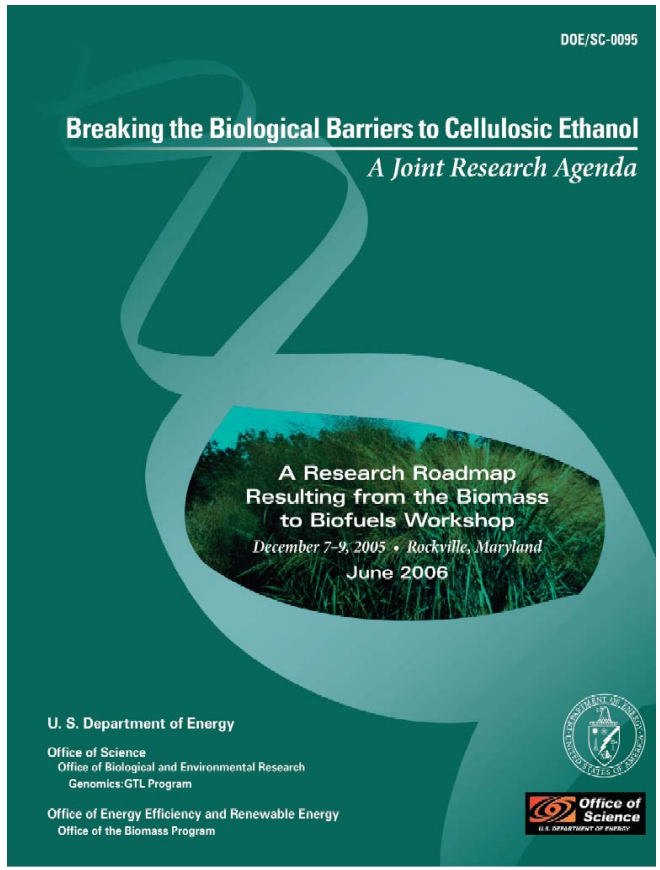
**Calibration Services:** Hydrocarbon Liquid Flow Meter calibration, Volumetric calibrations

**Alcohols and Ethers [Oxygenates] in Reference Fuels:** to calibrate instruments that determine alcohol content of gasoline

# Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda

## Published in June 2006

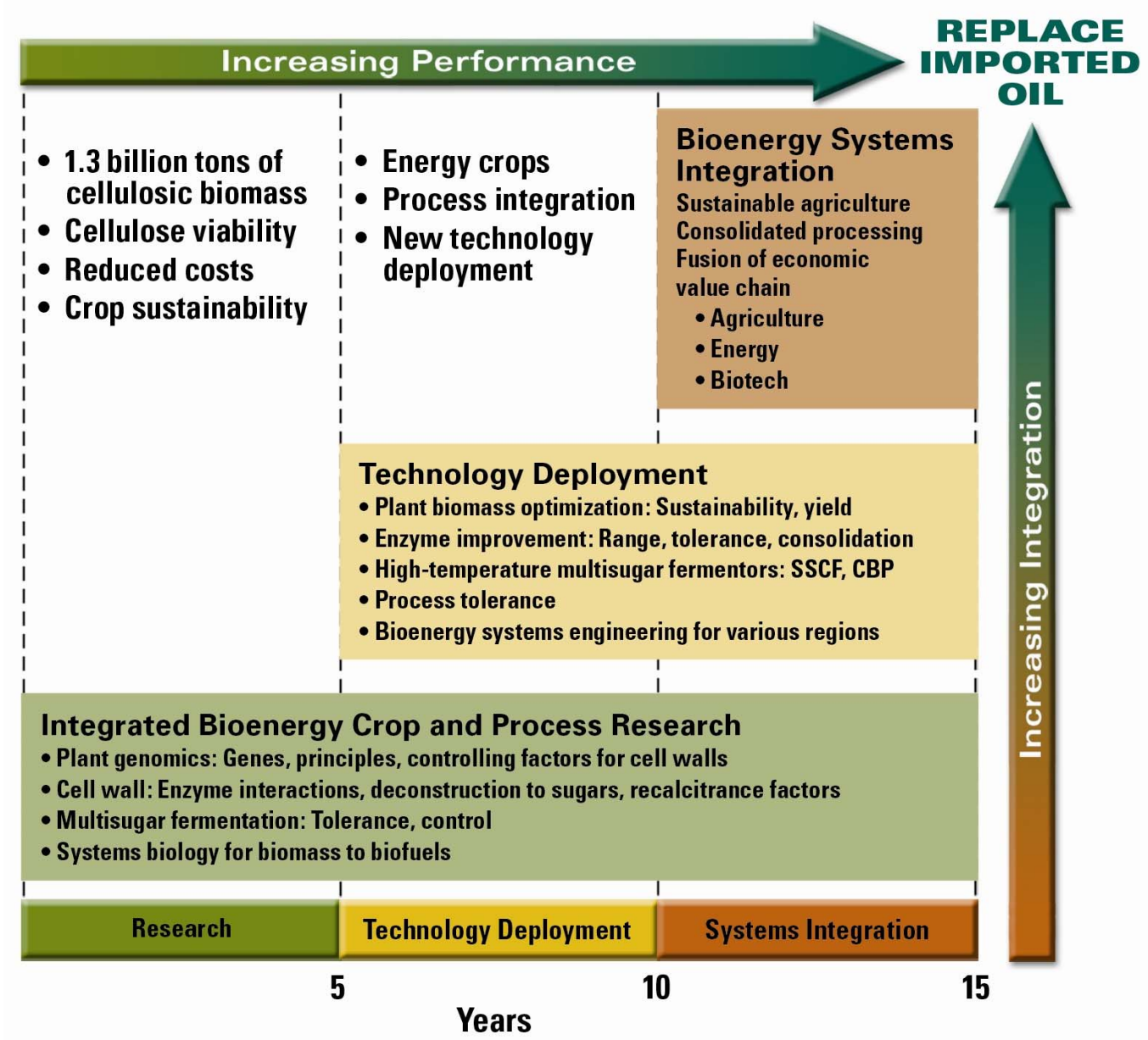
A Research Roadmap Resulting from the ***Biomass to Biofuels Workshop*** Sponsored by US Department of Energy (Dec 2005)



# Phased Development of Bioenergy Systems

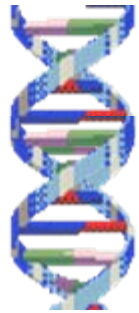
US DOE Genome Programs

http://doegenomes.org

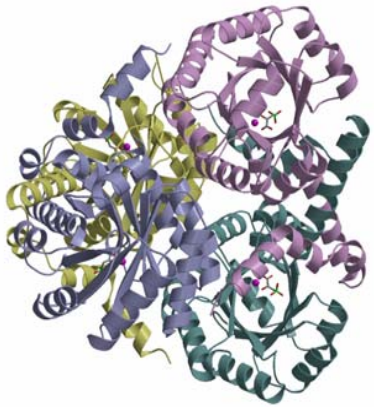


# Research Phase (underpinning 5-15 year timeline) Relevant NIST programs

- First-generation energy crops (designer crops)
  - Structural biology



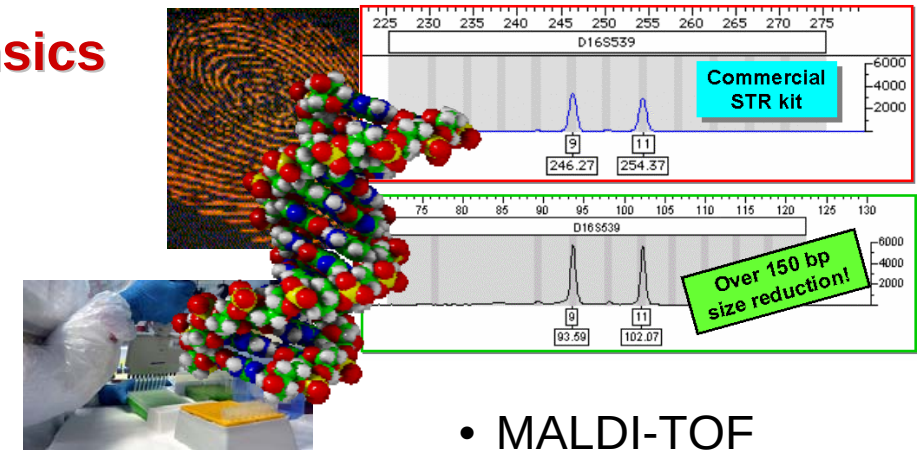
- Genome-based capabilities to identify genes involved in synthesis of cell-wall polymers
  - Cell and Tissue Metrology
  - DNA technologies
- The application of **new tools** such as:
  - Proteomics
  - Metabolomics
  - Imaging



# Genomics: DNA Technologies

## DNA-based standards for forensics

- Development of miniSTRs (short tandem repeats) for more sensitive STR typing
- Y chromosome DNA profiling standard (SRM 2395). This standard enables an expanding forensic, paternity, and genetic genealogy use of the Y chromosome

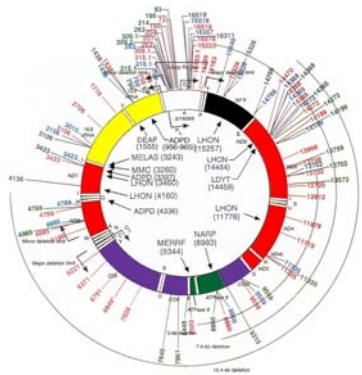



- MALDI-TOF
- DNA Sequencing
- PCR

## DNA-based standards to support healthcare

**SRM 2399, Fragile X Human DNA Triplet Repeat Standard**

- For genetic testing laboratories to check test procedures and for quality control



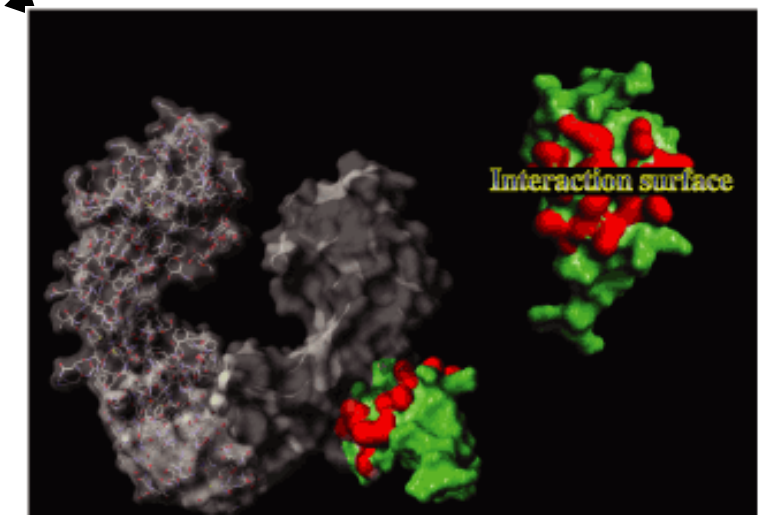
return

# Structural and Functional Biology

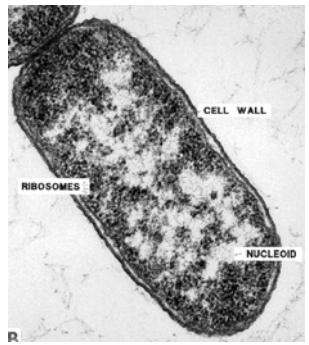
Structures from X-ray Crystallography
NMR Spectrometry, Cold Neutron
Research, and
Computation

***Plants***

***Marine Organisms***




***Human Tissues***




***Microorganisms***

Function, mechanism and
engineering through molecular
and physical biochemistry,
and computational biology

return

# Biotechnology Measurements Today: the "…omics era"

"Genomics"

DNA

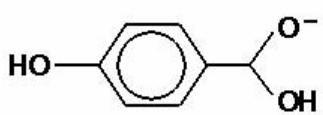
RNA

Proteins

"Transcriptomics"

"Proteomics"

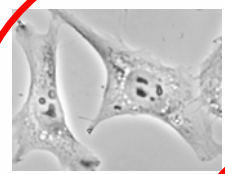
Products




Organism behavior

"Cellomics"

Cell and tissue behavior



"Metabolomics"

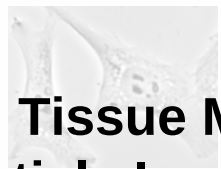
Metabolites

# Current Bio-Related Activities Throughout NIST

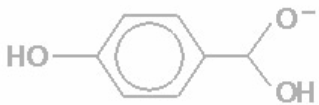
**DNA and RNA Science**
**Metrology for Gene Expression**
**Nanobiotechnology**

**Marine Bioscience and Health**
**Metrology for Drug Delivery Systems**
**Standards for Food Safety and Nutrition**

**Cell and Tissue Measurements**
**Nanoparticle Imaging in Tissue**
**Quantitative Cell Biology**



**Structural Biology**
**Standards for Clinical Proteomics**




**Standards for Metabolomics**

# Proteomics Today – The Goal

*The goal of **proteomics** is to identify and quantify all proteins in the cells, tissues from an organism.*

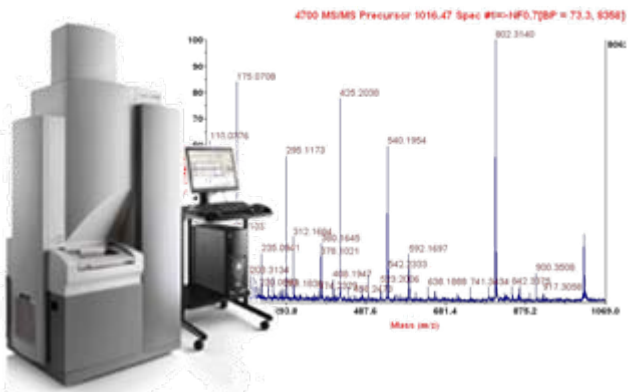
*Proteomics research can lead to development of new drug targets and identification of biomarkers of disease and treatment.*

NIST

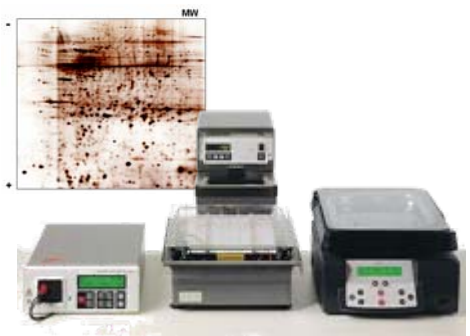
# Proteomics: Mass Spectrometry

- Identification of new proteins expressed in biological systems
- Improved sequencing methods of proteins
- Development of new *in vivo* and *in vitro* approaches to quantify changes in the levels of expression of these new proteins

***MALDI-TOF/TOF Analyzer***



***2-D Gel Station***




***Amino Acid Analyzer***

# Proteomics Today – The Problem

*"In order for proteomics to be accepted as a valid science in clinical medicine, it is vital that the experimental results be reliable and reproducible within the scientific community. The absence of these standards… is a barrier to innovation… and … delays the discovery and transfer of proteomic technologies into clinical applications."*

***-- Anna Barker, Deputy Director, NCI***

# Proteomics – The NIST Solution

- NCI has requested that NIST provide the proteomics community with a suite of proteomic standards to underpin and provide confidence in proteomics measurements

- In response to this need, NIST has initiated a strategic partnership with NCI to develop methods and standards
  - Reference methods and standards for individual proteins and simple mixtures
  - Plasma materials with assigned-values for these proteins
  - Reference mass spectra of peptide products from tryptic digests of proteins

# Metabolomics

***Metabolites*** *(small organic molecules) represent the end products of genetic expression.*

***Metabolomics*** *is the comprehensive analysis of large numbers of metabolites. These qualitative and quantitative relationships provide a holistic view of the biochemical status or biochemical phenotype of an organism.*

# Reference Methods & SRMs for Health Status Markers in Blood/Urine

## Reference Systems Currently in Place for **Many Well-Defined Markers** such as:

| Marker | Disease State |
|---|---|
| Calcium | Cancer, Blood Clotting |
| Chloride | Kidney Function |
| Cholesterol | Heart Disease |
| Creatinine | Kidney Function |
| Glucose | Diabetes |
| Lithium | Antipsychotic Treatment |
| Magnesium | Heart Disease |
| Potassium | Electrolyte Balance |
| Sodium | Electrolyte Balance |
| Triglycerides | Heart Disease |
| Urea | Kidney Function |
| Uric Acid | Gout |

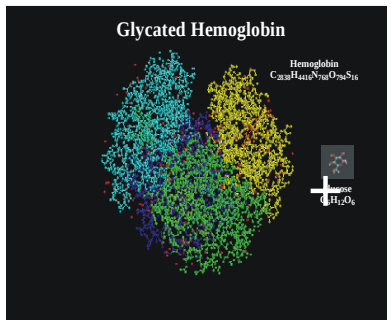
Glucose

***Characteristics of these Markers:***

- Relatively small well-defined molecular or elemental species
- Typically, can be determined using methodology well-studied and characterized by NIST for many years

## Reference Systems Being Developed for **New Markers** such as:

| Marker | Disease State |
|---|---|
| Troponin-I | Myocardial Infarction |
| Cortisol | Endocrine Function |
| C-Reactive Protein | Risk of Heart Attack |
| DNA Triplet Repeats | Fragile X Syndrome |
| Folates | Neural Tube Defects |
| Glycated Hemoglobin | Diabetes Status |
| HER2 | Breast Cancer |
| Homocysteine | Risk of Heart Disease |
| TSH, T3,T4 | Thyroid Function |
| Speciated Iron | Hemochromatosis |
| PSA | Prostate Cancer |



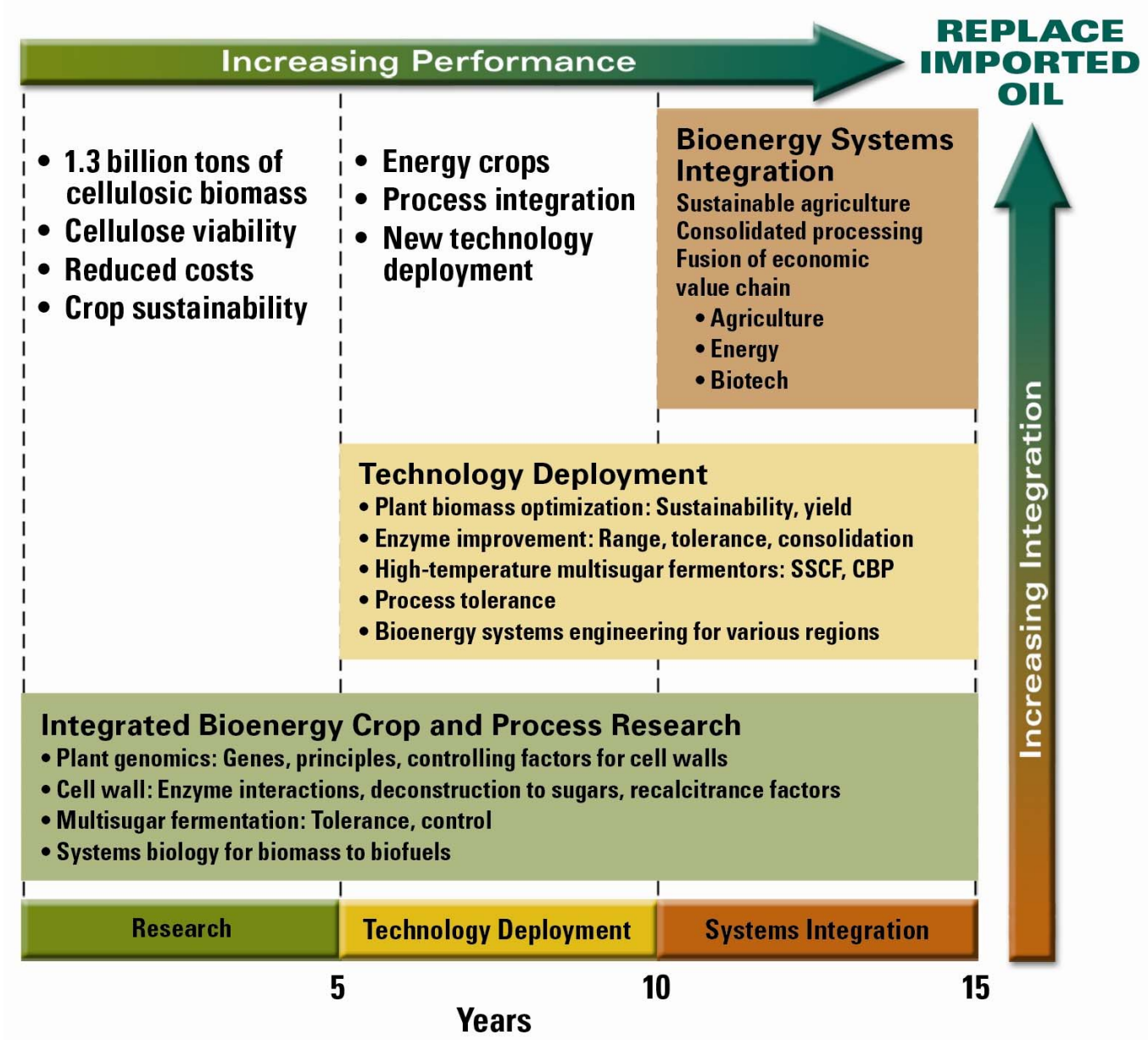

***Characteristics of most New Markers:***

- Proteins, peptides or DNA-based
- Heterogeneity and instability of analyte form
- Low concentration in blood or urine
- Cannot all be “standardized” using conventional analytical chemistry approaches

# Phased Development of Bioenergy Systems

US DOE Genome Programs

http://doegenomes.org



# Technology Deployment Phase
# Relevant NIST programs

- Bioprocess engineering
  - **Biothermodynamics, biospectroscopy, biocatalysis**
- Tools for rapid analysis and manipulation
  - **Cellular and sub-cellular measurements**
  - **Metrology for gene expression**
  - **High throughput chemical tools**
  - **Computational modeling**
- Tools for regulatory control
  - **Reference Materials and Data**
  - **Calibrations**

# NBS →NIST Mission

NBS Mission: To aid U.S. manufacturing and commerce

NIST Mission 2006:

To promote U.S. **innovation** and industrial **competitiveness** by advancing measurement science, standards and technology in ways that enhance economic security and promote our quality of life

Our original mission and our mission today challenges us to provide the measurement infrastructure to impact new areas related to commerce and increased quality of life as they develop

# *"Energy Crisis"*

## Timing is Right to Explore Alternative Fuels for Transportation

***The Biorefinery Initiative:***
***Accelerating research into "cellulosic ethanol" can make it cost-competitive by 2012, offering the potential to displace up to 30% of the current US fuel use.***

We must also change how we power our automobiles … fund additional research in cutting-edge methods of producing ethanol, not just from corn, but from wood chips and stalks, or switch grass. Our goal is to make this new kind of ethanol practical and competitive within six years.

**GW Bush**
**State of the Union Address, 2006**

# END